Bloch Surface Based Platform for Optical Integration

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Summary

A novel dielectric multilayer platform sustaining Bloch surface waves is investigated for integrated photonic chips. These surface waves can be manipulated by two dimensional dielectric optical components patterned on top of the platform. We study the properties of high refractive index materials (TiO_2) as active top layer of platform.

Concept

The Bloch surface waves (BSWs) are surface electromagnetic modes, which can be excited in the photonic band gap of truncated dielectric periodic multilayers. BSWs show the potential of higher propagation length and large resonance strength because of low loss characteristics of dielectric materials. These properties are highly desirable features for 2D optics. Another advantage of using BSWs is the possibility to work with any wavelength by properly choosing the refractive index and thickness of the layers constituting the multilayer. Furthermore, because the maximum intensity associated with the BSW can be tuned on the surface, a strong field intensity, increased by several orders of magnitudes, can be achieved and thereby enhance the light-matter interaction close to the surface. Taking the advantage of field confinement, the platform has an application in the integrated optics domain [1], and sensing [2]. A platform consisting of periodic stacks of alternative SiO_2 and Si_3N_4 layers is designed and fabricated to work around the wavelengths of 1.5 µm. Different optical elements can be fabricated on top of the platform by depositing and patterning an additional thin dielectric material. The presence of the additional layer modifies the local effective refractive index, enabling a direct manipulation of the BSW and introducing a refractive index contrast Δn between the additional layer and the platform. This refractive index contrast Δn, which can be deduced from the dispersion relations, plays a key role in managing the propagation of the BSWs on the platform. In order to excite a BSW, momentum of incoming beam should match with the momentum of the BSW. Therefore, we use Kretschmann configuration for this purpose, which consists of BK7-glass prism. The schematic of the configuration and the platform is presented in Fig. 1. Since the top layer is in the order of several tens of nanometers, a multi-heterodyne scanning near-field optical microscopy (MH-SNOM) that allows a simultaneous measurement of the amplitude and the phase is used for the optical characterization.

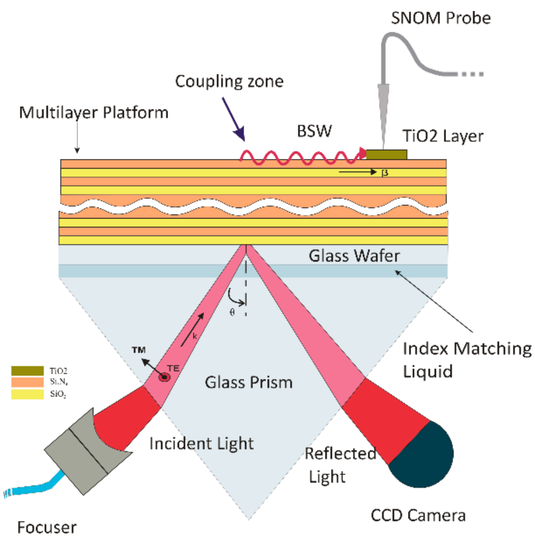

Fig.1. Kretschmann configuration using BK7-glass prism to excite BSW.

Propagation length and Effective refractive index analysis

In this paper, we study the propagation length and the effective refractive index of high refractive index materials, for example, TiO_2.They characterize the losses associated with the multilayer platform and the propagation of the surface modes. First, L_{BSW} for a bare multilayer and different thicknesses of TiO_2 have been measured experimentally. As shown in the Fig.2.(a), L_{BSW} is obtained by exponentially fitting the decrease of the field amplitude, over 300 µm, of the surface wave in the propagation direction. For 15 nm coating of TiO_2 on the platform, we achieved a propagation length of around 1.49 mm, which is ~18 times longer than the recently obtained “Long-Range SPPs” studied by Lin et al [3] and 2 times longer than the one studied by L. Yu [4]. The Near field image of BSW propagation has been shown in Fig.2.(b). We have also measured Δn in near field, with a MH-SNOM, for different thicknesses of TiO_2. Fig.2.(c) shows both simulated (matrix transfer) and measured Δn as a function of the TiO2 thickness. It has been proved from the far field measurement and simulations that a Δn of 0.2 can be achieved with 100 nm thickness of TiO_2, which is ~ 3.5 times higher than the Δn obtained for the same thickness of the Photoresist [4].

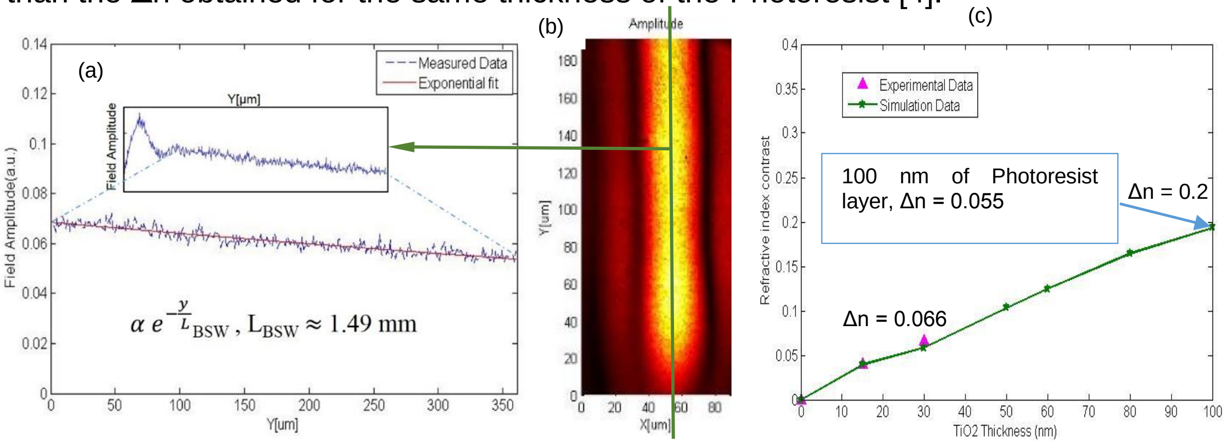

Fig.2.(a). Exponential fit of the field amplitude to measure propagation length of 15 nm TiO_2 thickness. (b). SNOM image demonstrating BSW propagation. (c) Plot of simulated and measured values of Δn for different thicknesses of TiO_2.

Conclusions

In this work, dielectric multilayers are proposed as a platform for a planner manipulation of the Bloch surface waves. We aim to characterize different optical components pattered on additional TiO_2 layer with the aid of MH-SNOM in the near-infrared, for example, Ring resonators and Interferometers for the time being. Experimental results show good agreement with simulation results. We obtained a propagation length of ~ 1.49 millimeters for 15 nm thickness of TiO_2 layer and a Δn of ~ 0.2 for 100 nm of TiO_2 measured in the far field.

References

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